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Performance Impairment and its Association to other Alterations in Cannabis users

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Abstract

Cannabis is the most frequently used drug worldwide. Its use is often associated to socioeconomic, academic and professional impairment. Although there are several damages resulting from its consumption, there are currently no studies which broadly explore why these performance impairments happen. This study is a narrative review, based on articles selected from Embase, Medline, PsycInfo and Web of Science databases. This study aims at exploring the performance deficits associated with Cannabis use, as well as the possible cognitive-behavioral, emotional and motivational alterations which may explain them.

Chronic Cannabis use leads to central nervous system changes, involving the endocannabinoid system (cerebral reward and cortical functioning system), resulting in deficits i several cognitive, behavioral, emotional and motivational domains. There is significant impairment in learning, attention, memory, decision making and inhibitory control, as well as an increase in depressive, anxious and dysphoric symptoms. These symptoms may be associated to poor academic performance, reducing chances of obtaining a degree, higher levels of study evasion, unemployment and work absence, lower salaries and higher need of financial aid. These results suggest that performance impairments related to chronic Cannabis use may be due to biopsychosocial factors, which are interrelated and contribute to losses in several domains of the users lives.

Keywords: Cannabis; Academic Performance; Professional Performance; Cognition; Motivation

Abbreviations: THC: Tetrahydrocannabinol; CBD: Cannabidiol; CNS: Central Nervous System; CRCFS: Cerebral Reward and Cortical Functioning System; IGT: Iowa Gambling Task.

Introduction

Cannabis is the most frequently used drug worldwide. Its use is a public health problem found mainly among young adults, especially in countries where people earn higher incomes [1]. According to data from the United Nation Office on Drugs and Crime, in 2014, Cannabis was consumed by around 182.5 million adults. This number corresponds to 3.8% of the world's population between 15 and 64 years old [2]. Consumption rate in Brazil, in 2012, was estimated to be 2.5% among adults and 3.4% among adolescents. Those numbers consist in over 3 million adults and 478 thousand adolescents [3]. Cannabis use pattern varies from recreational use to addiction. There is clear evidence that chronic use can lead to dependence. Dependence is diagnosed when a person meets three of the following criteria: I) spending too much time on Cannabis related activities; II) using it more frequently or for further time than intended; III) developing tolerance; IV) making several unsuccessful attempts to discontinue use; V) continuing using it despite associated physical and emotional impairments; VI) reducing or stopping participating in other activities despite Cannabis consumption; and VII) experiencing withdrawal symptoms [4-6].

According to data from National Survey on Drug Use and Health, in 2016, in the United States alone, about 4 million people over 12 years old have met criteria for Cannabis Use Disorder. This condition occurs when harm from recurrent use of this substance can be observed. Symptoms include health conditions, persistence or increase in use, and performance impairment in work, study and domestic activities [7]. Furthermore, it is important to point out that transition process between recreational use and dependence happens faster when in comparison to licit drugs – such as alcohol and tobacco [5]. Previous studies have demonstrated that affective self-regulation and relief of stress and/or anxiety symptoms are frequently primary motivation for Cannabis consumption. On the other hand, the attempt to self-medicate is also predictor of consumption frequency [8-11] and may be heightened by public misguided perception of this drug as harmless, with few harmful cerebral effects and low potential of causing dependence [12].

The main active principles of Cannabis are Δ-9-tetrahydrocannabinol (THC) and Cannabidiol (CBD). Evidences suggest that these compounds possess contrastive pharmacological properties – while THC has been associated to psychotic symptoms, studies on animal models suggest that CDB has effects on reducing or blocking convulsive episodes-as well as anxiolytic, sedative, antipsychotic, anti-inflammatory and antiemetic effects [13-15]. Δ-9-Tetrahydrocannabinol (THC) is an

endogenous agonist of cannabinoid receptors and it is the substance responsible for psychoactive effect of Cannabis [16]. Several recent data point out that, in countries with policies decriminalizing drug use, such as the United States, THC level found in this drug has been rising. One study dosed the amount of THC in confiscated samples and found that, in the last years, there was an increase of up to 4 times the THC concentration in street marijuana – from 3%, in 1980, to 12%, in 2012 [17].

This variation may be associated to an increase in the potential to substance dependence, especially when use is initiated during adolescence [4]. Higher THC levels may boost the impairments triggered by Cannabis consumption, resulting in anxious, depressive and psychotic symptoms and in higher risk of traffic accidents [4]. Moreover, Cannabis is related to increases in polydrug use frequency, raising the amount of harmful effects in cerebral development, cognitive deficit, motivational alterations, schizophrenic development and chronic symptoms of bronchitis in adolescents and young adults [6,18-20]. Yet, there is a popular misconception that its use causes little or no harm to a person's health, and there is even some "glamorization" of marijuana use in media. Some individuals still believe that using Cannabis may increase their motivation or improve their well-being [21,22]. Information on Cannabis reflexes in public health is controversial. Previous data demonstrated that Cannabis cost for public health is modest, accounting for only 0.2% of the total cost of diseases in Australia – country with one of world's highest indexes of Cannabis use [4].

Other investigations demonstrated that chronic and heavy Cannabis use is related to impairments on educational, work and socioeconomic performances, especially in terms of career delays and lower personal incomes. Still, neurobiological and psychosocial factors that explain performance loss are not defined in literature. There are no specific and more in-depth reviews on these factors and on their relation to performance impairments in comparison to non-users. Therefore, it is still not clear which are the symptoms, cerebral alterations and possible damages which could explain to health-care professionals, patients and families the association between Cannabis use and poor performance and productivity [6,23,24].

Objective

This study aims at revising emotional, cognitive-behavioral and motivational alterations deriving from acute and chronic Cannabis use, in order to elucidate and clarify its relation to users' educational and professional performances.

Method

This research is a narrative review, performed in Embase, Medline, PsycInfo and Web of Science databases. Several descriptors were employed, since it is a broad theme, in order to increase the scope of search. The terms selected comprehend prevalent alterations related to Cannabis use, cited on this theme reviews and discussed with a supervisor specialized in addiction (FHPK). The following terms were employed for this research: "academic achievement", "academic performance", "adverse effects", "amotivational syndrome", "anxiety", "apathy", "cognition", "cold cognition", "decision-making", "delay discounting", "depression", "educational attainment", "educational outcomes", "emotions", "executive function", "financial stability", "hot cognition", "life outcomes", "life achievements", "impulsivity", "motivation", "school difficulties", "school dropout", "school performance", "socioeconomic assistance", "unemployment" e "work commitment".

These terms were crossed with the terms "Cannabis", "marijuana", "THC" and "delta-9-tetra-hydrocannabinol". The search was performed on November 13th, 2018 and resulted in 38,152 papers. After reading titles and abstracts, 64 papers were selected for this review – preference was given for reviews, published in the last five years, containing historical relevance in the context of theories studied and published on high-impact journals. Cohort studies were also prioritized, since this study main goal is clarifying a possible causal association. Papers not written in or translated to English, and studies with samples containing other illicit drugs users concomitantly were excluded from this review. Among the 64 selected studies, 12 examined performance alterations, whereas the remaining studies examined cognitive, emotional and motivational alterations related to Cannabis use. Frequently, the same study contemplated more than one subtheme simultaneously.

Results

Firstly, main evidences related to poor educational and professional performances will be presented. Subsequently, alterations related to Cannabis use that may help understanding performance impairments origins will be presented, such as those related to central nervous system, and to cognitive-behavioral, emotional and motivational aspects.

Alterations on academic, professional and socioeconomic performances

Evidences suggest that chronic and heavy Cannabis use may be associated to educational underachievement and to losses on motivation, which might be potential mediators of poor functional performance [23]. In the United States, a report from National Survey on drug Use and Health, published in 2013, evidenced that 27.3% of individuals who abandoned high school and were aged to be in 12th grade were Cannabis users. In comparison to that, only 15.3% of individuals who were users still remained in school [25]. Thus, studies found out that early Cannabis use may be associated to educational performance loss and to an increased risk of school evasion. Furthermore, its heavy use may be associated to low incomes, high need of socioeconomic assistance, unemployment, criminal behavior and low satisfaction with life [6].

High Cannabis use levels during adolescence may precede higher unemployment levels, lower incomes at the age of 25 and lower salaries at the age of 29 [26,27]. An integrative metanalysis of three cohort studies, in Australia and New Zealand, evaluated the relationship between maximum marijuana use before the age of 17 and performance results analyzed up to the age of 30, in a sample of 2,537 to 3,765 individuals. In comparison to individuals who had never used Cannabis, daily consumers, before the age of 17, presented reduction up to 37% in high school graduation levels (OR of 0.37, 95% CI 0.20 a 0.66) and up to 38% in university degree acquisition (OR of 0.38, CI 0.22 a 0.66). Consequently, they presented higher Cannabis dependence rates, as well as illicit drugs use and suicidal attempts [23].

One study analyzed data gathered for eight years, from a cohort of 1,253 individuals from a public north-American university, with the objective of investigating if Cannabis use interferes in the mean score in university and in graduation time, using class absence as a measure for these outcomes. The study showed that marijuana consumption was linked to class absences rate, lower scores and longer time for graduation [28]. There might be an association between Cannabis use and academic environment impairments – even if we do not take into account individuals who dropped school, which could have also been Cannabis users. A longitudinal study was conducted during 25 years in order to examine the association between Cannabis use before the age of 21 and educational achievements, income, dependence on the State, unemployment, relationships and general life satisfaction at the age of 25.

The sample was composed by 1,003 individuals, and the mean amount of Cannabis use between the ages of 15 and 21 was identified. Young individuals who had used the drug 400 times or more had the highest use rate. The study showed that the higher the Cannabis use before the age of 21, the lower were levels of graduation and financial gain, thus, showing higher unemployment and dependence on the State. Furthermore, these subjects reported reduction in interpersonal relationships and general life satisfaction. This association was still made even after adjustments were made for confounding factors, such as comorbid mental illness and other substances use [20]. Another study evaluated 254 adolescents from upper middle class community during their four high school years. They were aged between 14 and 15 at the beginning of the study, and 17 to 18 by the end of it. Frequency of Cannabis use was annually checked. Official school registry of academic performance, as well as self-reported mental symptoms, were accessed between grades 9 and 12. Persistent use of Cannabis throughout these four years was associated to lower mean scores and to higher amount of symptoms in the 12th grade.

The association between Cannabis use and poor academic performance remained even when confounding factors of symptoms and 9 grade results were controlled. Effects became non-significant when controlled for alcohol and tobacco use [29]. Another longitudinal study also found an association between Cannabis use and worsen academic performance – however, the association remained when the confounding factor for alcohol and tobacco consumption was analyzed [30]. One hypothesis might be that academic impairment may had begun earlier, thus resulting in an underestimation of its decrease. So, it is supposed that low socioeconomic status may explain this association between Cannabis use, poor academic performance and mental health – nonetheless, this association has not been confirmed so far.

A recent study, conducted in Netherlands, investigated difference in academic performance among 4,323 students, comparing periods in which some of them, according to their nationality, had the possibility to acquire Cannabis legally. They analyzed 57,903 results from courses in the period between 2009 and 2012. The temporary restriction in legal access to Cannabis had a strong positive effect in scores of students affected by this policy – they showed a performance improvement of around 0.093 standard deviations, and 5.4% more chances of being approved in courses. Furthermore, the participants also referred to better understanding about the content of their studies in this period when they did

not have legal access to Cannabis – consequently, lowered its consumption [31].

A longitudinal study assessed the relation between path of marijuana use throughout life (since, approximately, 14 years old) of 548 individuals (from whom more than 90% were white) who were unemployed at the age of 43. Chronic users group (who started using marijuana at the beginning of their adolescence, reached a maximum amount of use in a weekly basis at the end of their adolescence and, since then, have progressively diminished its consumption), when compared to non-users, have three times more chance to be unemployed at the mean age of 43 (OR of 3.51, 95% CI 1.13 to 10.91), even after the results are controlled for possible confounding factors [32].

Finally, researches show that chronic and heavy marijuana users have higher rates of work absenteeism when compared to non-users [33]. The relationship between chronic Cannabis use since the beginning of adolescence and posterior unemployment may, also, be due to reduction in users productivity – resulting from their lack of working motivation –, diminished cognitive function, and mental and physical health problems [32]. Table 1 summarizes possible impairing effects of Cannabis use in socioeconomic performance and in study and work environments.

Performance Impairments	
Study Environment	Work Environment
Higher number of absences	Higher work absenteeism
Higher levels of school dropout	Higher chances of being uncapable for the job
Higher time for graduation completion	Higher chance of financial problems
Lower chances of acquiring university degree	Higher rates of unemployment
Lower chances of completing the studies	Higher need for socioeconomic assistance and higher financial dependence
Lower scores and poorer performances	Lower salaries and general income

Source: Created by the authors.
Table 1: Performance impairments associated to chronic and/or regular Cannabis use.

Cerebral, cognitive-behavioral and emotional alterations

Recent studies demonstrated that there are evidences of structural alterations in the central nervous system (CNS), in the medial temporal (amygdala and hippocampus), frontal and cerebellar areas, associated to exposure to Cannabis (18, 6). Chronic Cannabis use is associated to alterations in the CNS and in the endogenous endocannabinoid system, cognitive impairment and motivational alterations, mainly when consumption begins during childhood and adolescence, when there is the highest vulnerability to its effects [23,34-39]. Researchers suggest that individuals with substance use disorders have deficits in cognitive control, which limit their capacity to translate goals into adequate courses of action [40]. Imaging studies reported deficits in executive functions, evidenced by decreases frontal cortex activity, which interfere in decision-making, self-regulation, planning, inhibitory control and working memory [41].

Cannabis consumption impacts critical cognitive functions during the acute state of intoxication and for days after its use. It also causes acute impairments in attention, memory, working memory, reaction time, information processing, learning, executive functions (planning, reasoning, problem solving, interference control and decision-making), motor coordination and motor performance [18,42,43].Cognitive flexibility in decision-making is frequently altered by acute Cannabis use, with an increase in risk taking and reward sensitivity. Nevertheless, there is still no robust evidence, in systematic review and metanalysis, proving alterations in decision-making in Cannabis chronic users [43,44]. Some studies concluded that heavy Cannabis use for long periods results in persistent attention and memory impairments, which may worsen with its regular use along the years and are more pronounced if the use had begun during adolescence [6].

Neuroimaging and functional imaging studies in chronic Cannabis users demonstrated lower cerebral activity in regions involved in these functions in comparison to non-users, even after 28 days of abstinence [4]. There is also evidence of harmful effects from Cannabis use in the inhibitory control – alteration which is found, mainly, in heavy Cannabis users [45]. Other concordant data is that heavy users, even if not intoxicated, present worse performance than control individuals in neuropsychological tests. There are researches suggesting that long term deficits may be reversible or rest in a subtle level as long as the person remains abstinent from the drug [6,18]. A systematic review evaluated 105 studies on effects over cognition resulting from acute and

chronic Cannabis use. Memory and verbal learning were the most affected cognitive domains. Among executive functions domains, clear acute impairment was evidenced in behavioral inhibition domain, while other domains had inconsistent impairment evidence. After abstinence, some studies noticed improvement or recovery from the impairments in these functions, while others did not notice this pattern [43].

Cognitive Impairments	
Acute Use	Chronic Use
Verbal learning	Verbal learning
Attention	Attention
Executive functions (especially behavioral inhibition)	Executive functions
Memory	Memory
Working memory*	Working memory*
Psychomotor functions	Psychomotor functions
Decision-making*	Decision-making*

Source: Created by the authors.
* Data with lowest level of evidence. There are some studies showing that these impairments may not occur or may be reversible. The words in bold indicate alterations with higher level of evidence in current scientific literature [43].
Table 2: Cognitive impairments associated to acute or chronic Cannabis use.

A metanalysis, published in 2018, evaluated 69 studies and found that adolescents and young adults who are heavy/frequent Cannabis users presented small effect size (less than a third of the standard deviation) but statistically significant cognitive loss, when compared to control individuals (non-heavy users or non-users). Higher losses were identified in learning, long-term memory, executive functions, processing speed and attention. However, the authors point out these results do not support the conclusion that frequent Cannabis use is associated with a severe or medium-range cognitive impairment. Furthermore, when analyzing the studies which evaluated the individuals after a period of 72 hours of abstinence, there were no deficits found in cognitive domains, with a significant effect size [45]. A summary of results found can be observed in Table 2. Other information regarding alterations in decision-making will be described in the subsequent topic.

Acute Cannabis use may cause impulsive behaviors and lower inhibition of maladaptive responses- nonetheless, residual effects seem less consistent [44]. In this context, impulsivity is "a predisposition to fast and unplanned reactions to internal and external stimuli without considering the negative consequences of these reactions to themselves or to others", might be a reflection of immediate rewards desire or incapacity to postpone gratification and it is a key element in cognitive self-control and goal-directed behavior [46-48]. Impulsivity is an established risk factor for Cannabis use throughout life [40,49]. Impulsive behavior could be a preexisting personality trait, which would lead to drug use- nevertheless consuming Cannabis may lead to behavioral changes which include alterations in impulsivity [50]. Thus, illicit substances users could present these traits even more pronounced due to personal pre-existing characteristics, which does not mean using these substances would not exacerbate these characteristics.

The regular Cannabis use is also linked to anxiety and depression risk – notwithstanding, no causality was established for this last information [51]. A metanalysis performed in 2014, with 14 longitudinal studies, revealed that Cannabis users have a 17% higher chance (OR of 1.17 with CI of 1.05 – 1.30, CI of 95%) to develop depression, when compared to non-user controls. Users with a heavier pattern of Cannabis use (used the drug at least weekly) had 62% more chances to develop depression (OR of 1.62 with CI of 1.21 – 2.16, CI of 95%), when compared to light or non-users [52]. Moreover, another study demonstrated a relationship between reduction in Cannabis use and a decrease in depressive symptoms among young adult women who reported at least mild depressive symptoms [53]. Not all data showed clear association between Cannabis use and depression or anxiety symptoms. A study performed in Chile followed 2,508 students, with mean age of 14.5, throughout a period of 18 months; found that individuals with basal symptoms of generalized anxiety disorder, panic and depression used Cannabis frequently.

However, when the contribution of each factor was tested isolated, only the symptoms of generalized anxiety showed an independent association to the frequency of subsequent Cannabis use [OR of 1.25 (1.09 – 1.44 CI of 95%)], but with a small effect size [54]. Another study analyzed data obtained by a cohort study in Sweden, with 8,598 participants, with ages ranging from 20 to 64 years,

in a three-year follow-up. It was found that Cannabis use, in T0, was associated to a RR of 1.22 [1.06 – 1.42 CI of 95%] for depression and RR = 1.38 [1.26 – 1.50 CI of 95%] for anxiety. Nevertheless, when the result was adjusted for confounding factors (such as the use of alcohol and other illicit drugs, family tension, education and place of education), the association did not remain statistically significant. There was also an association between depressive and anxious symptoms at time zero, with increase in risk of using Cannabis after three years. However, the association did not hold when adjusted for other illicit drugs [55].

Motivational alterations and decision-making

Cannabis users have poorer performance in the Iowa Gambling Task (IGT) in comparison to non-users of drugs [56,57]. IGT is a laboratory test of decision-making which evaluates cognitive (learning and memory) and motivational processes (responsivity to losses and gains) [58]. Chronic users, when compared to control, were relatively insensitive to a magnitude of losses, more sensitive to an increase in the magnitude of gains and demonstrated higher dependence on recent results. These results suggest that psychological processes important in decision-making may also be compromised in chronic Cannabis users [58]. Historically, Cannabis use has been associated to reduction in motivation. Since the 70's, researchers started to further emphasize its effects on users' motivation, resulting from chronic use.

The term "Amotivational syndrome by Cannabis use" was proposed by McGlothlin and West, who described the syndrome as apathy and decrease in concentration, routine following and abilities to successfully dominate new material [18,59]. They affirmed that Cannabis use may lower activity level and willingness. Additionally, these individuals would care less about what happens in their lives, not work regularly, present fatigue and lack of worrying about their appearances [60,61]. There is preliminary laboratory evidence which supports the association between Cannabis use and motivation decrease for behavior related to reward in users, in comparison to controls [62]. There is also evidence that heavy Cannabis use for a long period is associated to educational underachievement and impairments in motivation-both proposed as potential measurements of poor functional performance [23].

There are several factors that could be related to motivation alterations resulting from Cannabis use, including brain alterations, such as a reduction in synthesis of dopamine in the striatum, reduction in levels of anandamide found in liquor, alterations in functioning of endocannabinoid system and in reward system of the brain. These alterations might be related to a negative emotional state, when in absence of Cannabis, resulting in negative reinforcement for abstinence and reducing the importance of motivational stimuli when compared to Cannabis [35,37,39,63]. Despite previously described alterations, there are studies which found dissonant results regarding effect of Cannabis use in motivation. One study published in 2006 assessed the level of motivation in a sample of 487 individuals, with ages between 18 and 81 years (mean age of 33.1), of which 243 were heavy Cannabis users (using it every day) and 244 had never used it. No difference was found in subjective motivation level between those groups, and individuals in both groups seemed relatively motivated [19].

However, it would have been more valuable if motivation had been measured in an objective, and not only subjective way. The fact that only self-reports were employed may limit this study results since apathy is, frequently, associated to insight impairment [43]. Also, heavy users could have cognitive alterations compromising their capacity of insight [38], which would contribute to the difficulty to realize the deficits caused by this drug use. In this sense, a research, performed in a community in Jamaica (in which there was generalized use of marijuana and a culture of its us), showed that chronic Cannabis users believed that its consumption resulted in motivational effects.

They were also convinced that it was beneficial and improved their capacity of hard working, reason why they argue to use it. The study compared workers productivity (cane cutters) – smokers of Cannabis (77 individuals) and non-smokers (82 individuals) – in three sugar cane camps, for three weeks. Results show that there was no difference in productivity among the groups. There was also no difference regarding their properties or their incomes [21]. However, sample size was considerably small, and the time of follow-up was significantly short. Research published in 2016 compared the effect of Cannabis use with and without cannabidiol in effort-related decision-making, in a group of 17 not heavy Cannabis users. Results showed that acute Cannabis use with cannabidiol reduces probability of choices demanding more effort, when compared to placebo. Another study was also presented, which assessed 40 individuals, among which 20 were Cannabis users, and 18 out of these used it daily.

Association between dependence on Cannabis, effort-relate decision-making, and reward learning was evaluated. No difference was found among the groups in EEfRT. However, Cannabis users' group presented higher

levels of depression and nicotine use [64]. THC effect may be modulated by cannabidiol, a non-psychoactive cannabinoid present in several Cannabis products [4]. The study employed small-N, thus, it is necessary to continue investigating cannabidiol effects on motivation. There is an existing hypothesis that cannabidiol may influence THC effect. This factor must be considered when evaluating the impairments resulting from Cannabis use. A systematic review of 22 studies, published in 2018, evaluated non-acute effects of Cannabis consumption on its users' motivation. Studies using multiple evaluating motivation methods were included (evaluation by self-reports, psychological testing and brain imaging studies). Authors concluded there is partial support for connection between chronic Cannabis use and motivation reduction – from the 22 assessed papers, 9 found this correlation.

The difficulty of getting definitive result occur due to: different definitions of motivation; different forms through which these parameters are tested; and the fact that many studies did not control the confounding factors in a more intense way (for example, comorbid depressive symptoms and use of other drugs). The study highlights that it is necessary to develop more studies about this subject in order to find more robust evidence [65]. Through evaluation of this data, it is not possible to establish causal link between Cannabis use and motivational alterations. Chronic and heavy Cannabis use may be the cause of deficits in motivation, but it is possible that the individuals had this deficit prior to Cannabis use, or that, from a previous deficit, there had been a worsening in motivation resulting from this drug use [18]. There are several criticisms to affirmations that Cannabis use generates reduction in motivation: many studies present methodology flaws, especially concerning the absence of a control group and of representative sample data. Also, many studies deal with multiple drugs users, hindering conclusions regarding the effect of a specific drug [66]. Another difficulty in exploring motivation in individuals with substance use disorder is that common psychiatric comorbidities (such as depression and schizophrenia) are independently associated to apathy symptoms [40].

Behavioral, psychiatric, physical and motivational alterations		
Acute Use	Chronic Use	Abstinence
Anxiety	Anxiety	Anxiety
Depression	Depression	Depression
Reduction in motivation	Reduction in motivation	Insomnia
Impulsivity	Impulsivity	Irritability
Decision-making	Decision-making	Decision-making
Lower inhibition of maladaptive responses	Psychosis*	Appetite increase
Psychosis*		Higher brain response to stress

Source: Created by the authors.

* It is estimated that Cannabis use increases risk of schizophrenia in, approximately, two times. Frequent or high doses use of THC increases risk of schizophrenia in six times. Most individuals who use Cannabis do not develop schizophrenia [18].

Table 3: Behavioral, psychiatric, physical and motivational alterations found in studies with Cannabis users.

Conclusion

From this review it is possible to conclude that there are evidences of association between deficits on academic, professional and socioeconomic performance and the chronic Cannabis use [6,20,24]. Evidences point out that these deficits are most likely to occur due to multiple and complex interaction of biopsychosocial factors. Factors responsible for these deficits are cognitive-behavioral, emotional, motivational and decision-making alterations, resulting from this drug use and, possibly, from social media and peer influence [24]. CNS damages also may be related to Cannabis use, which comprehend alterations in endocannabinoid system, in reward system of the brain, and in cortical functioning. These alterations are more pronounced when consumption is initiated during childhood, adolescence or at the beginning of adult age, since maturing brain is more sensitive to psychoactive substances effect [6,18,35,36].

Cannabis use may be associated to impairments in cortical functioning, mainly in pre-frontal cortex, with interference in decision-making, behavioral and emotional self-regulation, inhibitory control, impulsivity and the remaining executive functions, which can contribute to risk decision-making and increased sensitivity to rewards. It is important to highlight that cortical dysfunction is not restricted to the period of Cannabis abstinence [22,40,41,43]. Although there are distinct results concerning the possibility of Cannabis

users having motivational impairment, most papers show that this harm exists [18]. However, there are no systematic reviews or metanalysis studying this association in a definite form. One of the reasons why there could be distinct results in this domain might relate to THC levels found in Cannabis throughout the years. It raises questions about the pertinence of previous studies in Cannabis-caused impairments – especially studies which assessed long-term effects, given that it has been proved that higher THC concentration found in Cannabis is associated to harmful effects [4].

For example, from three papers that showed results of non-alteration in motivation resulting from Cannabis use, two were from the 70's. When the year of 2012 is compared with the 80's, it can be observed that percentage of THC found in samples confiscated in United States' streets increased by 400% [17]. Another point to be considered is that chronic Cannabis users may not be able to identify motivation impairments resulting from Cannabis use, since motivation alterations are directly related to their goals. Motivational alterations in heavy and chronic Cannabis users can be exactly related to desire and motivation to reach less ambitious goals, or ones which demand less effort. Thus, individuals may not reveal any harm in their motivation in self-applied questionnaires, since their objectives may be minor than if they were not heavy Cannabis users. Chronic and heavy Cannabis users may have got used to a new ambition standard, and their motivation may have been related to this standard. Cannabis itself can be a major motivation for chronic and heavy users. Thus, other activities may be placed in lower level in an individual rewards scale [18,37,40,60,66].

The environmental factor may also influence poor academic and work productivity of marijuana users, since their community may also take part in a subculture that does not emphasize academic success or its values – such as planning, punctuality, worrying about the future and reasoning [60,66]. One study found, yet, an association between Cannabis use and violent experiences, which may happen if where these individuals live, tend to be violent, or due to behavioral alterations related to Cannabis use. Peers effect must also be considered, since, especially among children, adolescent and young adults, Cannabis users have higher chances of having peers who also use it [24]. Among the limitations of this study, there is the fact that some research methods hinder its reproducibility, since the criteria for papers inclusion or exclusion were little specific and restrictive.

The seek and selection for papers were complex, wide and almost handcrafted, being aligned with main evidences and hypothesis on theme available in literature and with authors' experiences in the field. Another important point that most of the papers does not define what is a heavy Cannabis use. So, it was found divergence in this concept varying from use at least weekly up to at least three times a week. In epidemiologic studies, heavy or regular Cannabis use is defined as daily or almost daily use. However, this parameter was not applied in most of the papers, which compromises the comparison of their results in a narrative review [67]. On the other hand, this study is one of the first in literature broadly exploring the impairments in Cannabis users performance, leaving the most common strand – terror policy, which usually emphasizes more severe damages such as schizophrenia, but seems not to sensitize young people in general.

In this sense, we present a wide range of causal hypothesis (emotional, behavioral, cognitive, motivational and decision-making alterations, influence of social environment and peer effect) related to these evident functional impairments associated to Cannabis use, which may lead to this poorer performance. Based on the studies from this review, damages caused by Cannabis use are complex and hard to measure, which also complicates inferences about causalities. Yet, the sum of evidences resulted in gathering possible causal effects for performance impairments. This shows that Cannabis use, especially chronic use among young people, may trigger neurochemical alterations in brain systems. These alterations may generate anxiety, depression and dysphoria symptoms, as well as decrease in capacity of a series of cognitive functions.

This culminates in the phenotype of an individual with low motivation for complex tasks, high impulse for procrastination, little initiative and with alteration in values related to academic and work performances [8,37]. Finally, the study also managed to bring about important information for clinical practice, since it might be used for psychoeducation of patients and healthcare professionals about main collateral effects resulting from Cannabis use and the consequences of its use in extremely important areas in individuals lives. In the supplementary material of this paper it is possible to access a table with the main topics presented by each of the papers assessed in this study.

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